Center Independent Research & Development: JPL IRAD

Development of Planetary Protection Technologies for Special Region Missions (DPPTSRM)

Completed Technology Project (2015 - 2018)

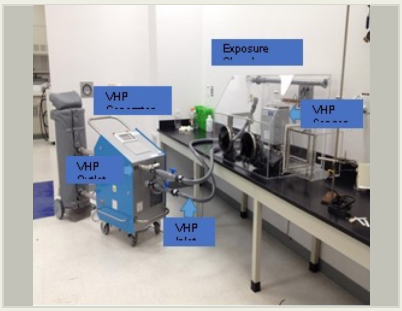
Project Introduction

The goal of the proposed work is to develop aseptic assembly techniques and investigate biobarrier/bioshield implementation approaches that obviate the need for subsystem and system-level dry heat microbial reduction (DHMR). The objectives of our proposed work are to develop aseptic assembly techniques and processes considering a variety of sterilization modalities; e.g., Vapor Hydrogen Peroxide (VHP), radiation, other potentially new techniques for utilization in an assembly and test environment. More specifically, we aim to
1. Evaluate the relative effectiveness of candidate aseptic assembly techniques in view of hardware with complex geometries, size scale up issues, and material compatibility issues.
2. Determine targets for research augmentation of approved modalities for more planetary protection credit against specifications.
3. Develop biobarrier/bioshield implementation options for prevention of recontamination.
4. Evaluate biobarrier/bioshield options for use both at the subsystem and the system level.

Our quantitative capability goal is to provide a four- to six-order-of-magnitude reduction in the spore microorganism load over the initial maximum density of 300 spores/m2, and to prevent the recontamination by any new spores.

The current state-of-the-art (SOA) of sterilization at Jet Propulsion Laboratory (JPL) has been limited to dry heat microbial reduction (DHMR). Vapor hydrogen peroxide (VHP) has been approved by the NASA Planetary Protection Officer (PPO), but the specification only provides time, rate, and H2O2 concentration levels for simple surfaces, and does not provide direction for complex geometries (e.g., vented boxes and electronics chasses inside the warm electronics box of a rover). The Europa Mission Risk Reduction effort has funded initial work in developing a portable approach to application of VHP to be used locally (e.g., at the site if hardware integration in a high-bay, or on the launch pad), but completion funding was not approved; further effort is needed to develop techniques and processes to develop the modality into a viable technique for spacecraft hardware application. Other modalities (e.g., radiation) may show promise for application to spacecraft hardware, but are untried, let alone approved for spacecraft hardware sterilization. The current SOA in sterilization modalities outside JPL is led by the medical and food industries, and their work provides promising technologies worth investigating for use on spacecraft hardware. The current SOA of biobarriers/bioshields at JPL is limited to the system-level biobarrier used on Viking and the subsystem-level biobarrier used on the Phoenix robotic arm. The Viking technology is old enough to require re-invention, and the Phoenix technology is limited in application instances. There are no space-qualified equivalents in industry outside JPL.

We will use the following methodology to achieve our sterilization objectives



Lab-based VHP Sterilization System

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over a 3-year funding plan:
1. Investigate the SOA in sterilization technologies outside JPL. We plan to survey technologies from the medical and food industries. 2. Down-select the most promising technology or two for further development and evaluate test efficacy on spacecraft hardware to provide a new sterilization alternative to DHMR. 3. Complete development of VHP technology for aseptic assembly of spacecraft begun by the Europa Mission project. This technology will provide a mature sterilization approach that not only can be used for sterilization of surfaces at the subsystem and system levels, but also provides a new capability for an electrostatic discharge (ESD)-safe in situ sterilization to be used during integration and/or rework of previously sterilized subsystems. 4. Prepare detailed procedures for the local use of VHP sterilization technologies at both subsystem and system levels. 5. Test spacecraft materials compatibility with the chosen sterilization modalities and compile database of both past and new materials compatibility data. 6. Integrate the above activities to complete the development of novel aseptic assembly techniques and processes.
To achieve our objectives with biobarriers/bioshields, we will 1. Survey and select the most likely subsystems of a Mars special region spacecraft that would require sterilization and protection from recontamination. 2. Incorporate design issues such as ESD control, coefficient of thermal expansion mismatch, catching on neighboring components/subsystems, venting, and reusability (if needed) into a preliminary design. 3. Identify and prepare preliminary designs for the two to three most viable biobarrier/bioshield options for both subsystem and system level implementations.
Regular engagement of our stakeholders will be maintained throughout the work to insure continued applicability to potential Mars special region mission concepts.

The successful implementation of PP constraints for a Mars special region mission will require the development of novel approaches and technologies for sterilization and recontamination prevention. Our innovation is seeking out and developing the most viable sterilization technologies in the SOA outside JPL and adapting them for use in spacecraft hardware applications. Novel developments will include developing aseptic assembly and in situ sterilization techniques using VHP (and perhaps other modalities), and preparing the first compilation of materials compatibility with VHP and other viable sterilization modalities. Furthermore, this work will produce the first new system-level biobarrier/bioshield design in 40 years, and will have additional options over the Phoenix robotic arm biobarrier.

Anticipated Benefits

Our task is seeking out and developing the most viable sterilization technologies in the state of the art (SOA) outside JPL and adapting them for use in spacecraft hardware applications. Novel developments will include

Organizational Responsibility

Responsible Mission Directorate:

Mission Support Directorate (MSD)

Lead Center / Facility:

Jet Propulsion Laboratory (JPL)

Responsible Program:

Center Independent Research & Development: JPL IRAD

Project Management

Program Manager:

Fred Y Hadaegh

Project Manager:

Fred Y Hadaegh

Principal Investigator:

Laura E Newlin

Co-Investigator:

Fei Chen

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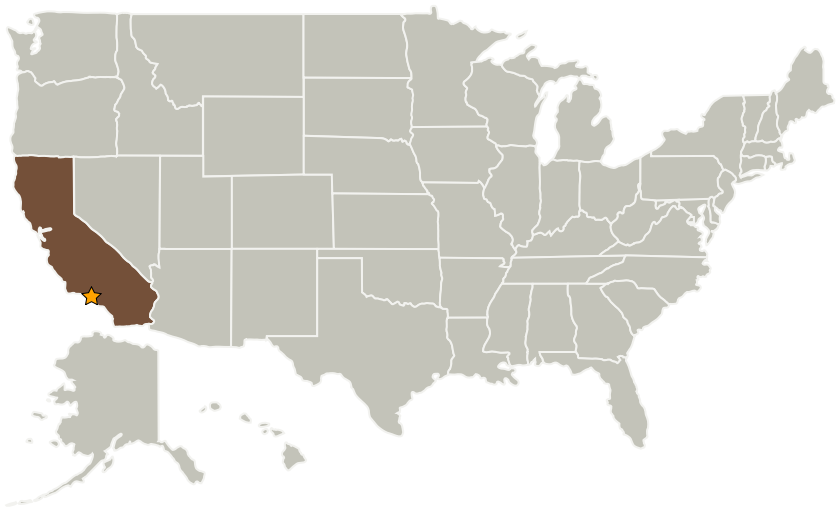
developing aseptic assembly and in situ sterilization techniques using vapor hydrogen peroxide (VHP) (and perhaps other modalities), and preparing the first compilation of materials compatibility with VHP and other viable sterilization modalities. Furthermore, this work will produce the first new system-level biobarrier/bioshield design in 40 years, and will have additional options over the Phoenix robotic arm biobarrier.

The benefits to NASA unfunded and planned missions are the same as described for NASA funded missions.

Our task published a summary of the current most viable sterilization technologies in the state of the art (SOA) outside JPL that can be adapted for use in spacecraft hardware applications. We will also publish our results in developinng new sterilization technologies for spacecraft hardware applications.

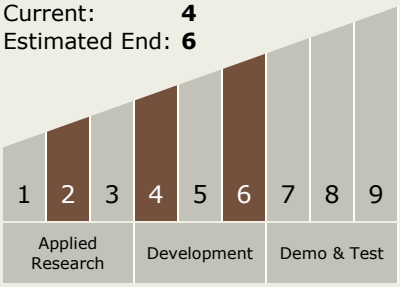
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Jet Propulsion Laboratory(JPL)	Lead Organization	NASA Center	Pasadena, California

Technology Maturity (TRL)

Start: **2**
Current: **4**
Estimated End: **6**



Technology Areas

Primary:

- TX07 Exploration Destination Systems
  - TX07.3 Mission Operations and Safety
    - TX07.3.5 Planetary Protection

Target Destinations

Mars, Others Inside the Solar System, Foundational Knowledge

Supported Mission Type

Push

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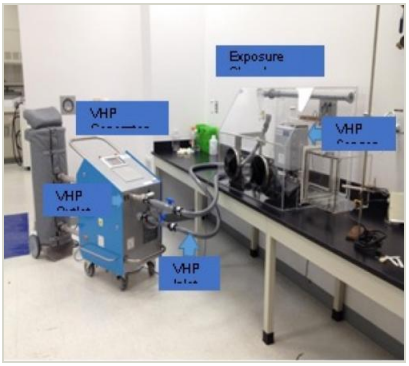
Primary U.S. Work Locations
California

Images



Lab-based VHP Sterilization System
Lab-based VHP Sterilization System *(https://techport.nasa.gov/image/24456)*